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RESEARCH ARTICLE

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EFFECT OF MESHES WITH GLASS FIBER ON MECHANICAL PROPERTIES OF FERROCEMENT PLATES

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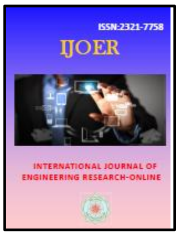

ABSTRACT

The cracking stress, Ultimate moment, Shear Strength, First crack moment, First crack Load and corresponding Deflection of ferrocement elements in shear and flexure are the significant parameters in the design of structures made of ferrocement elements. In this project I am going to presents an experimental investigation on ferrocement elements uniformly reinforced by three different meshes, such as Hexagonal mesh, Diamond mesh, square mesh with fiber of 1%, 2% and 3% of Glass fiber. In this paper I would like to study the cracking Stress, Ultimate moment, and shear strength and deflection properties of ferrocement elements by analyzing experimental data, the equations for the first-crack-stress, ultimate-moment and volume fraction have to made in this paper. Results obtained by the proposed equations have to be compared to those reported in the literature. For ferrocement and laminated cementitious composites, increasing number of mesh openings have to cast and bending test is going to conduct on those specimens. Ferrocement members can be used in the form of plates Such as for walling unit, marine structures etc. Such plates are subjected to shear buckling hence shear resistance capacity of plate need to be verified. Various authors have studied shear behavior on different specimens such as box beams, panels, and plates. In the present study an attempt is made to observe behavior of ferrocement rectangular plate with various mesh patterns.

Keywords: Ferrocement, Cracking stress, Bending Moment, Flexural behavior Shear Behavior of Ferrocement Plates (SBFP), ultimate load-deflection and meshes.

INTRODUCTION

Socio-economic factors have always influenced construction practices. Man has invariably attempted to compose materials that are not only cheap and easy to employ, but also strong and durable. Fibre composites being lightweight, eco-friendly, cost effective and structurally efficient, happen to be an ideal choice for construction industry. Ferrocement is one such composite material which consists of layered wire meshes and rich cement-sand mortar.

The uniform distribution and high surface area to volume ratio (specific surface) of the reinforcement results in a good crack arrest mechanism. It has high degree of ductility and energy absorbing capacity and has been increasingly used both in terrestrial and marine environments., Generally conventional reinforced concrete members are too heavy, brittle cannot be satisfactorily repaired if any damage develops cracks or reinforcement corrodes. The above disadvantages of normal concrete forced the use of Ferro cement concretes. Ferrocement techniques though of recent origin have been extensively used in many countries. There is a growing awareness of the advantage of this technique of construction all over the world. Ferrocement is a composite material constructed by cement mortar reinforced with closely spaced layers of wire mesh and 1%, 2%, 3% of Glass fiber. The ultimate tensile resistance of ferrocement is provided solely by the reinforcement in the direction of loading. The compressive strength is equal that of the unreinforced mortar. However in case of flexure or shear analysis and design of ferrocement elements are complex and are based primarily on the reinforced concrete analysis using principle of equilibrium and compatibility.

PRESENT STUDY AND OBJECTIVE

The study is also carried on the experimental and analytical investigations of the ultimate moment capacity and the plate with size of 500x150x30mm The mode of failures and the crack patterns were also observed. Variables chosen for the investigation were the single layers of mesh with different openings and shear span to depth (a/d) ratio with 1 to 3 sizes of ferrocement plates and Glass fiber. For ultimate moment capacity shear intensity, bending and cracking stress analysis by trial and error methods based on the principles of equilibrium and strain compatibility were used. Both methods have produced satisfactory results. The variation of shear force with a/d ratio along with different fiber percentages of single layer with two opening of mesh is examined. The experimental ultimate shear is compared with different code values (viz., AC1, BS, AC, and IS). The variation of ultimate moment of resistance and experimental shear is also examined with respect to volume fraction to and a/d. ratios. The variation of ultimate shear to the shear strength v_{cr} is observed with reference to volume fraction and different types of steel meshes are used. Those are Square mesh with,2mm and Hexagonal mesh with, 6mm and Diamond mesh with 12mm opening meshes are used in this present project.

MATERIALS USED

Ordinary Portland cement giving a 28days mortar (1:3) compressive strength of 53MPa and fine aggregate confirming to the requirements of ASTM-C-33 was used in the entire investigation. Steel square mesh, Hexagonal and Diamond mesh was used as reinforcement to the Ferro cement rectangular elements. The diameter of wire was found to be 0.56mm, 1.0mm and 1.5mm. The openings in the mesh are 2x2mm for square mesh and 6x6mm for Hexagonal mesh and 12x12mm opening for Diamond mesh. The ultimately highest yield strength was observed in hexagonal wires of the mesh was found to be 370Mpa, A cement Sand ratio of 0.50 and a water cement ratio 0.45 were used for casting the units. Ferro cement control specimens of rectangular plate size 500x150x30mm for shear and flexure test with 1,2,3% of glass fiber of specimens for flexural test were also cast along with the test units. The compressive strength of the mortar found to be 35Mpa. The constituent materials of ferrocement are cement, sand, water, steel reinforcement, glass fiber.

MORTAR MATRIX: For example the following mix calculation for 500x150x30mm size of the plate given below:

Mortar unit weight = 2000 kg / m^3

50cmx15cmx3cm = 2625 cm^3 = 2625 x 10^{-6} x mortar unit weight

= 2625 x 10^{-6} x 2000 = 5.25

= 5.25 / 4 = 1.31 kg

Cement = 1.31 x 1 = 1.31 kg

Sand = 1.31 x 3 = 3.93 kg

W / c = 0.45 = 0.45 x 1.31 = 590 ml of water

water = 590 ml

Fiber 1% : By cement weight = 1310 grams

Fiber 1% = 13 gm , Fiber 2% = 26 gm and Fiber 3% = 39 gm

OUTLINE OF EXPERIMENTAL PROGRAMME : The experimental investigation consists of casting and testing two series of rectangular plates ('A" , and B"). The " A "series represents the 500x150x30mm plate specimens with reinforcing as square mesh 1-layer of two mesh openings and each mesh opening we are casted one specimen in their cross section . The " B" series represents the 500x150x30mm plate specimens with reinforcing as square mesh 1-layer of two mesh openings and each mesh opening we are casted one specimen. with 1,2 and 3% of glass fiber. Finally elements are tested for after 28 days curing for the test of shear and flexure from this tests we can determined first crack load, first crack moment, ultimate load, cracking stress, shear strength, volume fraction first crack stress and ultimate moment and their corresponding deflection. Here, volume fraction and shear strength can be determined some theoretical equations. By

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observing in this study shear and bending values should be depends upon mesh type, thickness of mesh, size of the plate, mesh size and opening it varied. But in this project we got the best results for Hexagonal mesh of 6mm opening with thickness of 1mm. And if volume fraction increases automatically increases shear strength of the plate. But some situations it will decrease because of to increase the thickness of mesh and opening of the mesh. At the same time parameters also reduced like shear and bending. Finally we draw the optimum values of plates we can drawn the load-deflection curves

CALCULATION OF VOLUME FRACTION AND CRACKING SHEAR STRENGTH

Hence, It is worth mentioning that Hexagonal mesh improves the shear capacity over than that of diamond and square meshes because of it having a higher straight length. So, diagonal cracks increases strength as compare to other cracks. From these results it is observed Here, one calculation carried to determine volume fraction of steel meshes. Hence for example hexagonal mesh.

$V_f = N/4*\pi*dw^2/h*(1/D_L+1/D_t)$ → 1

Where, N = No.of mesh layers = 1

Dw = dia. of mesh = 1mm, π = 3.14

D_L = Distance center to center between longitudinal wires

D_t = Distance center to center b/w transverse wires

$D_L = D_t =$ 4mm & 6 mm

h = Thickness of ferrocement plate is 30mm

From equation 1 the volume fraction of plate = 0.003 & 0.01

Cracking shear strength of ferrocement plates which are having different volume fractions and mesh pattern.

$V_{cr} = (0.27 + V_f^{0.65}) * (f'c * H/a)^{0.65}$ *% of fiber → 2

From, equation 2

where, $V_f =$ volume fraction of mesh

f'c = Mortar compressive strength is 35 Mpa

a = shear span = 75mm

H = overall beam depth is 150mm

H/a = 150/75 = 2

Finally, first crack load , deflection ,ultimate load and corresponding deflection, volume fraction and cracking stress values are noted in following table.

The effective reinforcement (Rr) of the cement composite in a given direction is defined as the ratio of the area of mesh in that direction to the total area of the specimen in the same direction.

$R_r = (25*\pi*d^2*N_L) / D*$

$N_{cr} = (L * t* P_{cr}) / 12*I$

$\mathbf{M_{cr} = (M_t + 5.91xR_r) x t}$

Where, M_t = 1st crack moment for the section with Zero percent reinforcement

$M_{ult} = (0.0049 + 0.42 V_f x f_y/f'c - 0.077(V_f x f_y/f'c)^2) x f'c x b x t^2 x \eta$

where η = Global efficiency factor of mesh in the loading direction

f_y = Yield strength of reinforcement and V_f = volume fraction

t = Thickness of specimen

b = Width of the specimen and f'c = Mortar compressive strength

THE RELATION B/W CRACKING STRESS & ULTIMATE MOMENT $\mathbf{N_{cr} = (M_{ult} x t) / 2x I}$

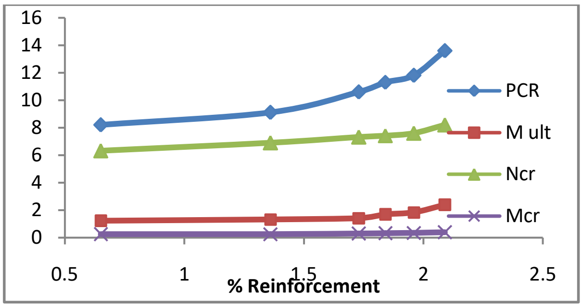
OVERALL GRAPHICAL REPRESENTATION: Finally, based on the results of ferrocement plates 3% of glass fiber got the best results of shear and flexural parameters with the variation of varias meshs and mesh types as reinforcement.

The following graphs can be divided into two groups. Those A and B

A. Effect of Percentage of reinforcement.

B. Effect of meshes

GROUP-A: By the effect of percentage of reinforcement three mesh types varies the shear and flexural parameters like N_{cr}, M_{ult}, P_{cr} and M_{cr}. But Hexagonal mesh 6mm opening specimens gives the best results shown in below



Hexagonal mesh with 6mm opening specimens

GROUP-B: By the effect of meshs with three mesh types varies the shear and flexural parameters like N_{cr}, M_{ult}, P_{cr} and M_{cr}. But Hexagonal mesh 6mm opening specimens gives the best results shown in below:

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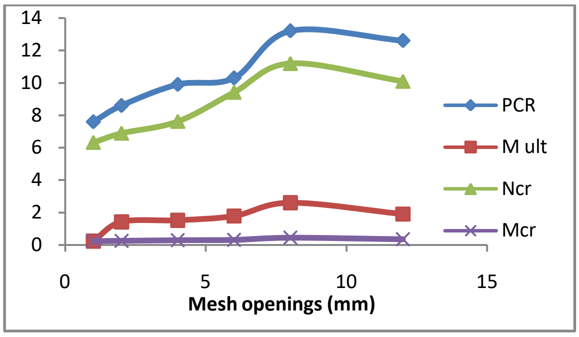

Hexagonal mesh opening of plate specimens

Finally, from the above all graphs shows the first crack moment, ultimate moment, cracking stress and cracking load with effect of percentage of reinforcement and mesh openings. In this 3% of hybrid fibers of hexagonal 6mm mesh of specimens are the best results obtained.

DISCUSSIONS: EFFECT OF SHEAR AND BENDING:

Finally, from the bending and shear results we observed following issues discussed below:

EFFECT OF ADDITION OF GLASS FIBERS:

Finally, by using 1%,2% and 3% of glass fiber in the ferrocement plate mortar matrix the optimum value is 3% of glass fiber specimen gives the 50% of results when compared to remaining fiber percentages of plate 500x150x30mm size of plate.

CONCLUSION: Based on the results and observations of the experimental, the analytical study presented in this thesis and considering the relatively high variability and the statistical pattern of data. The main purpose of the present work, to check the suitability of cracking stress, ultimate moment, shear strength, first crack load, ultimate load, volume fraction and corresponding deflection of the ferrocement rectangular plate elements.

From the results of number of Ferrocement specimens tested and some conclusions can be drawn as follow:

1. The cracking loads slightly increased as the reinforcement volume fraction increased and the cracking loads were dependent on the mesh type and opening of the mesh.
2. The Flexural capacity of the composite plates increased with the increase of the specific surface area of the mesh.
3. The shear and flexural capacity of plates should be increased with increases the percentages of 1, 2 and 3% of glass fiber.
4. The rate of increase of both the cracking stress and ultimate bending moment are maximum for ferrocement contains Hexagonal mesh and are the least for the square mesh.
5. The load at which the load-deflection relationship started to deviate from the linearity and the extent of the plastic deformation varied with the type of steel mesh in the ferrocement plates.
6. One of the main advantage of ferrocement plates is that it can constructed with low cast housing compared to R.C.C structures.
7. And it decreases the self weight up to 20-40%. so, ferrocement structures can be used in minor structures.
8. The proposed equations for the first crack stress, first crack moment and ultimate moment ofthe flexural ferrocement elements are simple but provide reasonably accurate results as compared to relatively more complicated equations involving many parameters.
9. Flexural first crack stress, first crack moment and ultimate moment increased with the increase in percent effective reinforcement for any type of meshes.
10. For the ferrocement plates with light weight mortar under flexural loading, increasing the number of openings leads to an increase in the ultimate load, cracking stress, cracking moment and corresponding deflection.
11. From the results ultimate values for hexagonal mesh of 6mm opening mesh with 3% of glass fiber when compared to conventional ferrocement rectangular plate.
12. With this results we conclude that if volume fraction increases the shear intensity of plate also increases and it depends upon the opening and thickness of mesh.
13. The Hexagonal mesh cracking stress, cracking and ultimate moment and ultimate load-deflection increases with increase of addition glass fiber.
14. Finally, we increase the effective % reinforcement of a different type of meshes to increases the first crack stress, first crack

moment, ultimate moment, first crack load and shear strength. But in this project we got the ultimate results for hexagonal mesh 6mm opening of mesh with 3% of glass fibersof rectangular ferrocement plate element.

15. From this results we conclude that the ferrocement structures are cost effective and light weight structures when compared to R.C.C structures. Because, in this ferrocement plates mortar matrix was used there is no coarse aggregate content. So, it is in light weight and also it should be satisfy the strength parameter

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